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# Epidemics of Septoria Tritici Blotch and Its Development over Time on Bread Wheat in Haddiya-Kambata Area of Southern Ethiopia

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**Abstract**

Bread wheat (Triticum aestivum L.) is one of the important cereal crops in Ethiopia. It is widely grown in most of the regions in the country, including Southern Nations Nationalities and Peoples Region (SNNPR); however its production is affected by abiotic and biotic factors. Among the biotic factors, Septoria tritici blotch (Septoria tritici) (STB) is one of the important problems of wheat production in the country; including Haddiya-Kambata areas of SNNPR. A field experiment was conducted at Hossana and Angecha in 2012 main cropping season to quantify the severity of Septoria tritici blotch and its rate of progression over time Three different spray intervals (10,20 and 30 days) of propiconazole (Tilt 250 EC) and one unsprayed plot for each of the three varieties (Alidoro, Galama and Gambo) were used to create different STB epidemic levels. Treatments were arranged in randomized complete block design (RCBD) with factorial arrangement in three replications. The epidemic of STB was developed at both locations. Severity on all leaves (i.e. the leaves except flag leaf) and on flag leaf was recorded independently at weekly intervals. Due to different number of scorings and inconsistence of growth stages of crop during STB assessment at both locations, Analysis was made separately for the two locations. At Hossana, maximum severity of 78% of STB was recorded on all leaves of the variety Gambo and 76% on Galama. At this location severity of 74% and 57% were recorded on flag leaf of Gambo and Galama, respectively. At Angecha, maximum severity of 59% and 33% were recorded on all and flag leaves of Gambo, respectively. Based on their coefficient of determination ($R^2$), Gompertz model was best fitted than logistic for estimation of disease progression parameters. At Hossana on flag leaf, maximum progress rate of 0.074 gompit/day was calculated on unsprayed plot of Gambo and every 30-days sprayed plot of Galama and the progress rate of 0.058 gompit/day was calculated on all leaves of unsprayed plot of Gambo. The highest standardized AUDPC of 46.7%-day on flag leaf were calculated on unsprayed plots of Gambo at Hossana. The study showed that, STB disease epidemics was occurred at both locations. The highest level of severity and fast progress rate was recorded on unsprayed plots of all variety under the study with; including variety Alidoro that was previously reported as moderately resistant on other locations. Moreover, level of severity and disease progress rate is affected by varieties and number of frequency of fungicide spray. On susceptible variety the disease reduced the grain yield was reduced from54qt/ha at controlled plot to 32.3 qt/ha on natural epidemic.
**Keywords:** wheat, Septoria tritice blotch, severity, progress rate, Area Under disease Progress Curve

## 1. INTRODUCTION

Wheat belongs to the family Gramineae and to the tribe Hordea. The term wheat is normally used to refer to the cultivated species of the genus *Triticum*. Among many wheat plants, only three species are commercially important. These are bread wheat (*Triticum aestivum* L.*)*, durum wheat (*Triticum turgidum* L.) and emmer wheat (*Triticum compactum)*. But, now day cultivation is restricted almost entirely to the tetraploid durum wheat (*triticum turgidum* L.) and hexaploid bread wheat (*triticum aestivum* L.). From the two of them, hexaploid bread wheat is the most grown throughout the world. This includes the vast majority of varieties, which show great diversity in agro-ecological adaptation and utilization (Peterson, 1965; Knott, 1989; Gooding and Davies, 1997).

Wheat is an important cereal crop in Ethiopia that is widely cultivated in a wide range of altitude of high and mid agroecologies; ranging from 1500 to 3000 m.a.s.l. The most suitable area, however, falls between 1700 and 2800 m.a.s.l (Hailu, 1991; Bekele *et al*., 1994; Ethiopan ATA, 2013). It is produced exclusively under rainfed conditions.

In Ethiopia, however wheat productivity has increased and more than 65% of cultivated wheat farms are with improved cultivars the average national productivity is not more than 2.2 t/ha against the best performers and model farmers who managed to produce more than 6 t/ha (EIAR, 2012). Again this average national productivity is much less than 3 t/ha; it is the average world productivity (FAOSTAT, 2009).

This low average productivity which is below potential yield is because of the frequent abiotic and biotic stresses that are prevailing during critical growth stages of the crop. Among the most prevailing biotic stresses, STB caused by *Septoria tritici* (teleomorph: *Mycosphaerella graminicola*) is one of the major leaf disease (Eshetu, 1986; Mengistu *et al*., 1991: as cited in Abreham, 2008; Ethiopian ATA, 2013).

Diseases caused by *Septoria spp.* are economically important in all wheat producing areas of the world including Ethiopia (Hershman, URL: http://www.ca.uky.edu,April 17, 2012). *Septoria tritici* can cause grain yield losses from 30% to more than 70% (Eyal *et al*., 1987).

In Ethiopia this disease is widely distributed over all wheat growing areas. In most of them its severity is very high. According to survey report of (Eshetu, 1986; Mengistu *et al*., 1991: in Abreham, 2008) the yield loss of wheat as the result of this disease reach up to 82% at hot spot areas on susceptible varieties.

Although the problem is there, there is no enough information with regards to the development and temporal dynamics of wheat *Septoria tritici* blotch (*Septoria tritici).* So, to determine disease management strategy and time, understanding the development and rate of progress over time of the disease in relation to host growth are important epidemiological factors that determine the level of yield loss. Therefore, the objectives of this study were; to quantify the severity of *Septoria tritici* leaf blotch and its rate of temporal progression on bread wheat.

## 2. MATERIALS AND METHODS

### 2.1. Experimental Site

The experiment was conducted at two research sites of Areka Agricultural Research Center (ArARC) i.e. Angecha and Hossana, both of which represent the high lands of major wheat production areas of Southern Nations Nationalities and peoples Region (SNNPR) with high rainfall and are expected to be the suitable environment (hot spot) of the disease (Fikre, 2010).

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### 2.2. Experimental Materials and Treatments

The experiment was conducted using three bread wheat varieties (Alidoro,Galama and Gambo) that are moderately resistant, moderately susceptible and susceptible to *Septoria tritici* blotch and relatively resistant to other diseases like wheat rusts (Ethiopian crop registration directory of 1995, 2005 and 2011).

Multiple levels of *Septoria tritici* blotch epidemics been created in experimental plots through the application of propiconazole (Tilt 250 E.C.) at different intervals of time. Tilt is a systemic fungicide effective against almost all cereal fungal diseases. The fungicide was applied at a rate of 0.5 l/ha (125 g a.i. $ha^{-1}$) in three different spray schedules viz., every 10, 20 and 30 days. The ten-day sprayed treatment had been started immediately as *Septoria tritici* leaf blotch symptom appeared; on 03 and 17 of September 2012 at Hossana and Angecha, respectively. The 20 and 30-day spray interval treatments started two and three weeks after onset of disease, respectively. Then spraying continued at the specified intervals until the crop attained its physiological maturity. Unsprayed plots were included for each variety to allow maximum *Septoria tritici* blotch development for comparison of the effect of disease levels on different parameters.

### 2.3. Experimental Design and Treatment management

The experiment was laid out using Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. There were a total of 12 treatments of combinations of three levels of varieties and four levels of fungicide spraying frequencies. Each plot was consisted of 6 rows of 5 m length. The space between rows, plots and replications had been 0.2 m, 1 m and 2 m wide, respectively. Seed rate of 150 kg/ha, which is recommended for the area, had been used. Fertilizers at a rate of 23 kg/ha N and 46 kg/ha $P_2O_5$ were applied during planting and weeds controlled by hand weeding. Planting was done in July 20 and 23 / 2012 at Hossana and Angecha, respectively on previous year wheat cultivated field to increase inoculum potential. At both locations the land was ploughed four times by oxen.

### 2.4. Data Collection

#### 2.4.1. Disease data

*Septoria tritici* blotch severity was assessed on 10 randomly selected pre-tagged plants per plot at weekly interval from the time of disease appeared until the crop attained its physiological maturity. Severity on flag leaf was recorded independently. The average severity from the 10 plants per plot was used for analysis. During disease assessment, the growth stage of the crop was recorded to correlate the epidemic onset and disease progress in relation to wheat phenology based on the decimalized key developed by Zadocks *et al.* (1974).

STB severity was scored visually using a double-digit (00 to 99), modified version of Saari and Prescott's scale (Eyal *et al*. 1987; Saari and Prescott, 1975.) for wheat foliar diseases. The first digit (*D*1) indicates disease progress in plant height and the second digit (*D*2) refers to severity measured as the diseased leaf area. For each score, percentage of disease severity was estimated based on the following formula:

% Severity = $(D1/9) \times (D2/9) \times 100$ (Saari and Prescott, 1975)

2.5. Data Analysis
2.5.1. Analysis of variance (ANOVA)
Data on *Septoria tritici* blotch severity from each assessment date, yield and yield components, AUDPC and all agronomic data were subjected to analysis of variance by using the methods described by Gomez and Gomez (1984) using SAS computer software. Least Significant Difference (LSD) values were used to separate differences among treatment means.
2.5.2. Disease progress curve modelling
Area under the disease progress curve (AUDPC) was calculated and again growth curve models was developed from the disease severity data recorded at weekly interval on natural epidemic plots of the three varieties in order to show the pattern of diseases development over time under natural epidemcs. AUDPC values were calculated for each plot using the following formula (Wilcoxson *et al.*, 1975) and standardised by dividing the value by total number of days with in the range of scoring dates.

AUDPC=$\sum_{i-1}^{n-1} 0.5\,(x_{i+1} + x_i)\,(t_{i+1} - t_i)$

Where, $X_i$= the cumulative disease severity expressed as a proportion at the $i^{th}$ observation,
$t_i$ = the time (days after planting) at the $i^{th}$ observation and
n= total number of observations.

Since *Septoria tritici* blotch severity had been expressed in percent and time (t) in days, AUDPC values been expressed in %- days (Wilcoxson *et al.*, 1975). Then AUDPC values used in analysis of variance to compare amount of disease among different treatments.
2.5.3. Disease progression rate analysis
Logistic, ln [(Y/1-Y)], (Van der Plank 1963) and Gompertz, -ln[-ln(Y)], (Berger, 1981) models had been compared for estimation of disease progression parameters from each treatment. The transformed data has been regressed over time (DAP) to select the better fitted model. The goodness of fit of the models was tested based on the magnitude of the coefficient of determination ($R^2$). Then the appropriate model (Gompertz) was used to determine the apparent rate of disease increase (r) and the intercept of the curve. These parameters used in analysis of variance to compare the disease progress among the treatments.

## 3. RESULTS AND DISCUSSION
The experiment was planted in July 20, and 23 2012, at Hossans and Aangecha, respectively. It was harvested at the beginning of December 2012 at both locations. During the cropping season, intensity of the rainy was high up to the end of September and then it became very low at the latter growth stage of the crop. At both locations in the experimental field early leaves maturity was observed. This is might be the combined effect of shortage of rain fall and STB infestation (Magboul *et al.*, 1992).

3.1. Epidemics of *Septoria tritici* Blotch
3.1.1. Disease onset and its severity level on all leave (the leaves except flag leaf)
*Septoria tritici* blotch was first observed and recorded on 03 September 2012 at Hossana, at Zadoks growth stag (GS) of Z15, 23 (five leaves on main shoot & three tiller) on all experimental plots and infector rows. This could be due to sufficient airborne ascospores over the area as an inoculum (Ponomarenko *et al.*, 2011). The field was free from other foliar diseases like stem rust, leaf rust and yellow rusts at the growing season on both locations.

At Hossana on Alidoro, severity on unsprayed plot was significantly different from every ten days sprayed plot for the assessment dates of 80 (GS Z63), 87 (GS 70.5), 94 (GS 70.8) and 101 (GS 75) DAPs. On Alidoro, the highest severity recorded on every 10, 20 & 30 days sprayed and unsprayed plots were 21, 26, 39, and 60%, respectively on 101 DAP (Table 1). This showed level of disease development is considerably affected by level of fungicide application frequency. On Galama, STB severity assessed every 10 days sprayed and unsprayed plots showed significant difference after 73 DAP (GS Z45) (Table 1). On this variety statistically significant difference was observed between every 10 and 20 days intervals sprayed plots was beginning from 87 DAP (Table 1).

On Variety Gambo (susceptible) STB severity showed significant difference between unsprayed and every 10 days sprayed plots starting from 59 DAP (GS Z31 (Table 1). It is three weeks earlier than on Alidoro and two weeks earlier than on Galama varieties to show significant difference between their respective plots of every ten days sprayed and unsprayed plots. Moreover, on Gambo STB developed fast compared with Alidoro and Galama (Table 1). It confirmed on natural epidemics; latent period and the rate of disease development are affected by resistant level of the crop (Eyal *et al.*, 1987). On this variety, STB severity at terminal scoring date was 30, 71, 75, and 78% on every 10, 20 & 30 days interval sprayed plots and unsprayed plots; respectively (Table 1.). At the end, severity on every 10 days sprayed plot of this variety showed 61% lower than unsprayed plot.

At Angecha, STB first appeared on 15 September 2012 at crop growth stage (GS) of Z30 (stem start to elongate) and with relatively low level of intensity compared with at Hosanna. Here, on variety Alidoro, disease development showed significant difference between unsprayed plot and every 10 days sprayed plot starting from 68 DAP (GS Z43). On this variety, maximum severity of 35% was recorded on unsprayed plot followed by 31% of severity on every 30 days sprayed plot (Table 2).

At Angecha; STB severity level on Galama showed significant difference between unsprayed plot and every ten days interval sprayed plots starting from 68 DAP (GS Z38). On this variety, STB severity of 19, 43, 53 and 57% were recorded on final assessment date (103 DAP) from every 10, 20, 30 days sprayed and unsprayed plots, respectively (Table 2). On Gambo, beginning from 68 DAP (GS Z43) STB severity recorded on unsprayed plot showed significant difference from every ten days sprayed plot. It was at late growth stage than at Hossana. It showed the rate of STB development was low at Angecha. Here on Gambo, Maximum severity of 59% was recorded on unsprayed plot (Table 2).

On both locations, on all leaves the highest severity of STB recorded during the last assessment date on unsprayed plots of all varieties compared with their respective sprayed plots. It was 60, 76, and 78 % at Hossana (Table 1) and 35, 57 and 59% at Angecha (Table 2) on Alidoro, Galama and Gambo, respectively. As the results showed, the highest severity was recorded on unsprayed plot of Gambo (78% at Hossana and 59% at Angecha). Again, the lowest severity was on every 10 days sprayed plot of Alidoro (21%) at Hossana and 16% at Angecha).

At both locations on all varieties, development of STB showed continuous increasing (fig. 1). How ever there was difference on their significance, there was variation on STB severity among different spray intervals with in each particular assessment dates for all treatments.

Disease progress curve showed typical sigmoid shape on all and flag leaves of unsprayed plots of Galama,Gambo and Alidoro (fig.1 & 2). It is typical characteristics of polycyclic disease. But it was affected by resistant level of the varieties.

3.1.2. Disease onset and its severity level on flag leaf

At Hossana, symptom of STB first observed on Gambo on DAP 73 at crop growth stage (GS) Z60 (the whole spike visible, no yellow anthers) with severity level of 0.37, 1.47, 17.33, 11.69% on every 10, 20, 30 days intervals fungicide sprayed and unsprayed plots respectively. Finally, diseases severity on unsprayed plot reached 74% on 101 DAP severity (Table 3). At the terminal scoring date (101 DAP) STB severity reached 29, 56 and 74% on unsprayed flag leaves of Alidoro, Galama; respectively.

It revealed that development of STB at later growth stage of the crop was on progress, even though environmental condition was not suitable; low rain fall (1.4mm on both October and November). But, maximum temperature did not exceed 25 $^0$C; which was 21$^0$C, 23$^0$C and 24$^0$C on September, October and November respectively. This is agreed with the idea of Susceptible varieties could be infected even though under unfavourable climatic conditions (Sebei and Harrabi, 2008). it also supports the idea that " where the moisture period is short, an increase of temperature up to 25$^0$c may still result in sever levels of disease" (Hess and Shaner, 1985).

Like at Hossana, STB was first observed on flag leaf of Gambo at Angecha on 82 DAP (GS 69); while flag leaf of Alidoro and Galama remain free. At Angecha, on flag leaf the maximum STB severity of 5% on Alidoro, 10% on Galama & 33% on Gambo were recorded from unsprayed plots and the minimum severity of 2% on Alidoro, 0.41% on Galama, and 11% on Gambo were recorded from every 10 days sprayed plots (Table 3). So over all STB severity on flag leaf at this location was very low compared with at Hossana.

In this study, different epidemic levels were achieved by applying fungicide in deferent intervals of days; however it was not significant at early crop growth stage or for first few severity assessment dates (Table 1 & 2). At both locations the highest severity was recorded on Gambo; which is susceptible to STB, consistently for all epidemic levels (i.e. every 10, 20 & 30 days sprayed and unsprayed plots) compared with their respective severity levels on Galama and Alidoro on both all and flag leaves. The lowest severity was recorded from every 10 days sprayed plot of Alidoro. According the result, all varieties under the study were found to be susceptible including Alidoro, which was previously

Table1. *Septoria tritici* blotch severity at different days after planting on all leaves of three bread wheat varieties (Alidoro, Galama, and Gambo) at Hossana in 2012 main cropping season.

| Variety | Spray interval (day) | Number of spray | Severity (%) DAP | | | | | | | | | Grain yield (qt/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 45 | 52 | 59 | 66 | 73 | 80 | 87 | 94 | 101 | |
| Alidoro (MR) | 10 | 7 | 0.72c | 2.18d | 3.54d | 9.26c | 13.05f | 15.60f | 16.95f | 19.30d | 21.23f | 49.37bc |
| | 20 | 3 | 1.01bc | 3.25abc | 6.17abc | 11.11c | 18.72ef | 19.30ef | 20.78ef | 23.70d | 26.09ef | 48.2bcd |
| | 30 | 2 | 0.93bc | 3.09abc | 5.93abc | 11.00c | 22.47def | 28.02d | 31.40d | 35.56c | 38.60d | 44.3def |
| | No spray | 0 | 0.78bc | 2.63cd | 5.60bc | 11.81c | 22.51def | 28.31d | 45.10c | 53.87b | 59.92c | 43.6ef |
| Galama (MS) | 10 | 7 | 0.95bc | 2.96abc | 4.90cd | 10.24c | 13.49f | 19.09ef | 22.18f | 23.86d | 27.32ef | 51.3ab |
| | 20 | 3 | 0.86bc | 2.83bcd | 5.68bc | 10.86c | 18.23ef | 20.00ef | 26.33de | 33.09c | 45.67c | 45.6cde |
| | 30 | 2 | 1.11bc | 3.54ab | 6.87ab | 14.81bc | 29.88bcd | 36.58c | 58.60b | 69.71a | 72.63a | 40.8fg |
| | No spray | 0 | 1.01bc | 2.92bc | 6.13abc | 11.48c | 26.67cde | 39.47c | 60.16b | 71.44a | 76.05a | 36.7h |
| Gambo (S) | 10 | 7 | 1.52a | 3.42ab | 5.80bc | 14.12bc | 19.62ef | 22.63de | 25.10ef | 27.04cd | 30.35de | 54.3a |
| | 20 | 3 | 1.03bc | 3.13abc | 6.91ab | 20.95ab | 35.60bc | 41.28c | 45.88c | 60.21b | 71.44a | 46.7cde |
| | 30 | 2 | 1.11bc | 3.21abc | 6.71ab | 24.49a | 38.19b | 50.95b | 63.74ab | 73.45a | 74.90a | 37.6gh |
| | No spray | 0 | 1.13ab | 3.66a | 7.37a | 21.23ab | 48.11a | 60.78a | 70.41a | 77.78a | 77.78a | 32.3i |
| SE(N=3) | | | 0.25 | 0.45 | 0.87 | 4.50 | 4.94 | 3.24 | 5.04 | 4.64 | 4.99 | 2.4 |
| LSD 0.05 | | | $0.41^{ns}$ | $0.73^{ns}$ | $1.45^{ns}$ | $7.31^{ns}$ | 9.73 | 6.50 | 8.66 | 8.74 | 8.75 | 4.1 |

DAP = days after planting, SE = standard error of the mean, LSD = list significant difference

- Means flowed the same letters has no statistically significant difference.

Table 2. *Septoria tritici* blotch severity at different days after planting on all leaves of three bread wheat varieties (Alidoro, Galama, and Gambo) at Angecha in 2012 main cropping season.

| Variety | Spray interval (day) | Number of spray | Severity (%) DAP | | | | | | | | Grain yield (qt/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 54 | 61 | 68 | 75 | 82 | 89 | 96 | 103 | |
| Alidoro (MR) | 10 | 6 | 0.66bcd | 1.89d | 3.21c | 5.14g | 8.52h | 10.65g | 13.17f | 15.80h | 50.2bc |
| | 20 | 3 | 0.51d | 1.54d | 5.76b | 10.12def | 12.26fgh | 15.39efg | 19.09ef | 25.86fg | 47.6cd |
| | 30 | 2 | 0.78abc | 2.13bcd | 6.13b | 12.02de | 17.28ef | 20.16de | 23.66de | 30.74ef | 46.2d |
| | No spray | 0 | 0.70bcd | 2.02cd | 5.23b | 11.07def | 13.95fg | 18.06def | 25.64cd | 35.19e | 45.1de |
| Galama (MS) | 10 | 6 | 0.78abc | 2.14bcd | 3.29c | 6.42fg | 8.27h | 11.15fg | 13.49f | 18.89h | 52.5ab |
| | 20 | 3 | 0.62bcd | 1.93cd | 5.06bc | 11.98de | 14.23fg | 23.54d | 31.03c | 42.92d | 50.1bc |
| | 30 | 2 | 0.74bcd | 2.06cd | 5.67b | 14.81cd | 19.55de | 33.66c | 41.60b | 52.77bc | 45.4de |
| | No spray | 0 | 0.56cd | 1.85d | 5.72b | 19.05abc | 23.00cd | 43.13a | 49.30a | 57.38ab | 44.4de |
| Gambo (S) | 10 | 6 | 0.82ab | 2.55abc | 5.31b | 8.60efg | 10.00gh | 12.22fg | 15.06f | 20.49gh | 53.8a |
| | 20 | 3 | 0.82ab | 2.72ab | 11.03a | 17.98bc | 26.50bc | 35.76bc | 42.34b | 50.13c | 52.2ab |
| | 30 | 2 | 0.80ab | 2.72ab | 11.73a | 20.41ab | 28.64ab | 41.85ab | 46.95ab | 53.58abc | 46.6d |
| | No spray | 0 | 0.88a | 3.00a | 12.10a | 23.00a | 33.25a | 43.09a | 51.15a | 59.34a | 42.4e |
| SE(N=3) | | | 0.14 | 0.37 | 0.97 | 2.86 | 3.08 | 4.14 | 3.83 | 3.61 | 1.5 |
| LSD 0.05 | | | 0.25 | 0.65 | 1.93 | 4.71 | 5.32 | 7.22 | 6.42 | 6.33 | 3.4 |

DAP = days after planting, SE = standard error of the mean, LSD = list significant difference

- Means flowed the same letters has no statistically significant difference.

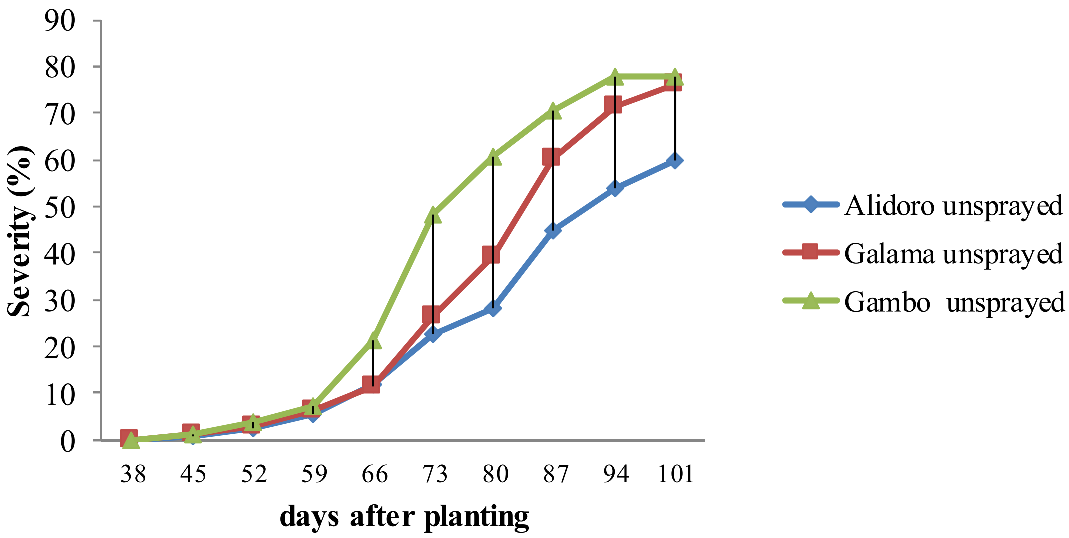



Figure 1. *Septoria tritici* blotch progress curve under natural epidemics on Alidoro, Galama and Gambo all leavs, at Hossana in 2012 main cropping season.

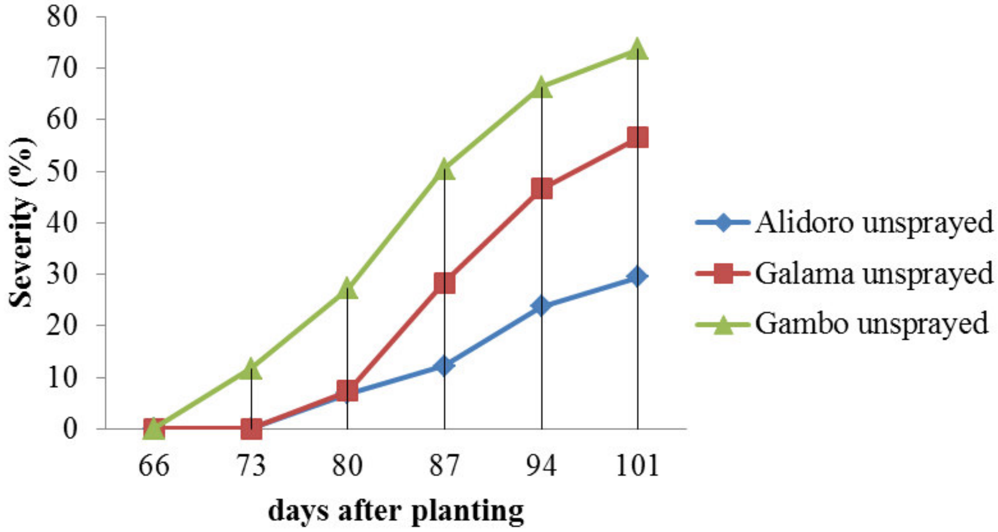



Figure 2. *Septoria tritici* blotch progress curve under natural epidemics on Alidoro, Galama and Gambo flag leaf, at Hossana in 2012 main cropping season. reported as moderately resistant on other location. This share the idea of "often wheat cultivars reported as resistant in one region have been found to be susceptible in another due to the genetic composition of the local pathogen population, which can be affected by cultivars grown, the suitability of the environment for infection, and the relative importance of the sexual stage in the disease cycle (Eyal *et al*., 1987; Agrios, 2005; Ponomarenko *et al*., 2011)".

The time for appearance of STB symptom on flag leaf was different accordingly with respective resistance level of varieties and frequency of fungicide sprayed. On flag leaf, STB symptom appeared first on variety Gambo, followed by Galama and then on Alidoro at both locations. This also confirms that the effect of crop resistant level on the latent period of pathogen and it support the result on Viljanen-Rollinson (2005). "Latent period of *Septoria tritici* is long on resistant variety than susceptible one".

3.1.3. Disease Progress rate

Both logistic and Gompertz models were tested to choose the best fitted one in describing the rate of *Septoria tritici* blotch. The coefficient of determination ($R^2$) was large for Gombpertz model than logistic for all severity assessments made on both all and flag leaves, except few at both locations. Hence, based on their determination coefficient ($R^2$), Gompertz model was better than logistic model and used to determine rate parameter.

*Septoria tritici* blotch progress rate was different among spray intervals with in the variety and as well as among varieties. At Hossana, on all leaves at every 10-days sprayed plots of variety Alidoro, Galama and Gambo, *Septoria tritici* blotch progress rate was 0.021, 0.023, and 0.023 gompit per day respectively. The progress rate on unsprayed plots of Alidoro, Galama and Gambo were; 0.041, 0.054 and 0.058 gompit per day respectively (Table 4). When compared with their corresponding every 10 days sprayed plot, it was faster by 1.78 times on Alidoro, 2.35 times on Galama and 2.5 times on Gambo than in every 10 days sprayed treatments. More over, the progress rate on unsprayed plots of Gambo (0.058 gompit per day) exhibited 1.1 times greater than the rate on unsprayed plot of Galama and 2 times greater that of the rate on unsprayed plots of Alidoro.

At Angecha, STB progress rate on all leaves of variety Alidoro was 0.020, 0.026, 0.028, and 0.030 gompit per day on every 10, 20, 30, and on unsprayed plots respectively. But, these were 0.021, 0.036, 0.042 & 0.047 logit per day on Galama; and 0.021, 0.040, 0.042 & 0.046 gompit per day on Gambo (Table 4).

On flag leaf, the highest progress rate of 0.074 logit per day was calculated on every 30 days sprayed plot of Galama and unsprayed plot of Gambo at Hosanna. The rate of 0.049 gompit per day was calculated for unsprayed plot of Gambo at Angecha (Table 5). The rate of *Septoria tritici* blotch development on unsprayed flag leaf of Gambo was faster than on its all leaves at both locations. As the result, the progress rate of STB was high on flag leaves of unsprayed plot of Gambo at both locations.

Table 3. *Septoria tritici* blotch severity at different days after planting on flag leaves of three bread wheat varieties at Hossana and Angecha in 2012

| Variety | Spray interval(day) | Hossana | | | | | Angecha | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Severity (%) DAP | | | | | Severity (%) DAP | | | |
| | | 73 | 80 | 87 | 94 | 101 | 82 | 89 | 96 | 103 |
| Alidoro (MR) | 10 | 0.00d | 0.00e | 0.00g | 0.67e | 0.77g | 0.00d | 0.00e | 0.56d | 2.00ef |
| | 20 | 0.00d | 0.00e | 0.81g | 1.66de | 6.60fg | 0.00d | 0.00e | 1.45d | 3.77de |
| | 30 | 0.00d | 0.44de | 2.19g | 3.37de | 4.68fg | 0.00d | 0.11e | 1.30d | 2.89def |
| | No spray | 0.00d | 6.84b | 12.26d | 23.70c | 29.45d | 0.00d | 0.30de | 1.26d | 4.78d |
| Galama (MS) | 10 | 0.00d | 0.00e | 0.00g | 1.47de | 1.83g | 0.00d | 0.00c | 0.00d | 0.41f |
| | 20 | 0.00d | 1.13cde | 2.92fg | 4.07de | 11.22ef | 0.00d | 0.48cde | 0.93d | 2.78def |
| | 30 | 0.00d | 2.56cd | 7.69e | 19.80c | 46.83c | 0.00d | 2.59de | 4.07c | 10.37c |
| | No spray | 0.00d | 7.33b | 28.41c | 46.66b | 56.48b | 0.00d | 1.37cde | 6.04c | 10.11c |
| Gambo (S) | 10 | 0.37d | 3.21c | 6.19ef | 9.02d | 17.90e | 0.00d | 0.41de | 1.48d | 11.30bc |
| | 20 | 1.47c | 2.58cd | 11.91d | 21.73c | 28.17d | 0.93c | 1.85cd | 6.04c | 13.85b |
| | 30 | 17.33a | 28.11a | 33.14b | 43.14b | 59.08b | 2.59b | 7.26b | 8.37b | 12.63bc |
| | No spray | 11.69b | 27.22a | 50.41a | 66.29a | 73.70a | 4.52a | 10.56a | 19.67a | 33.24a |
| SE(n=3) | | 0.52 | 1.4 | 2.13 | 4.43 | 4.77 | 0.42 | 1.03 | 1.18 | 1.60 |
| LSD 0.05 | | 0.86 | 2.38 | 3.75 | 7.66 | 7.90 | 0.71 | 1.73 | 2.04 | 2.70 |

DAP = days after planting, SE = standard error of the mean, LSD = list significant difference

- Means flowed the same letters has no statistically significant difference.

In general disease progress rate was high at variety Gambo. The lowest rate was calculated on Alidoro, on which it is moderately resistant followed by Galama; which is moderately susceptible. It agreed with disease development rate is affected by the resistant level of the crop and it is high on susceptible and low on resistant ones (Temesgen *et al*., 2000; Khelghati *et al*., 2003 and Elizabeth, 2012).

3.1.4. Area under disease progress curve

Calculated values of standardized Area Under Disease Progress Curve (StAUDPC) values on all and flag leaves at both locations were standardised by dividing it with its total number of days between the first and last assessment dates. It is to make the values uniform. StAUDPC value illustrated significant differences among all treatments on both all and flag leaves. The maximum values of 25 %-day on Alidoro, 32.1%-day on Galama and 41.1%-day on Gambo were recorded on all leaves on un sprayed plots; at Hosanna (fig. 3A).

At Angecha, StAUDPC value for all leaves on unsprayed plots of variety Alidoro, Galama, and Gambo were 13.4, 24.4 and 28 %-days respectively (fig. 3B). These values were lower by 46.4% on Alidoro, 24% on Galama, and 31.9% on Gambo as compared to values obtained at Hossana. Here, StAUDPC on every 30 days sprayed and unsprayed plots were not significantly differed each for Gambo and Alidor (fig. 3B). This indicates that on susceptible varieties less frequent (2 times) application of fungicide can't give good STB management (Ghaffary, 2011; Burke and Dunne, 2008).

At both locations, the highest StAUDPC on flag leaf was calculated on unsprayed plot of Gambo. These were 16.4 %-days at Angecha and 46.7%-days at Hossana (fig. 3A & B). Every 10 days fungicide application reduce AUDPC value on flag leaf by 98% on Alidoro and Galama, and 85% on Gambo at Hosanna and by 60.4% on Alidoro, 98.4% on Galama and 84.7% on Gambo at Angecha when compared with their corresponding unsprayed plots. In general, calculated StAUDPC values on flag leaf of all treatments were lower than all leaves at both locations, except on unsprayed plot of Gambo at Hosanna. This might due to combined effect of fungicide (Rezgui *et al*., 2008) and unfavourable weather condition for the development of STB at later growth stage of the crop (Agrios, 2005; Bockus *et al*., 2010).

Table 1. *Septoria tritici* progress rates on all leaves of three bread wheat varieties under natural epidemic and different fungicide spray intervals (days) at Hossana and Angecha in 2012.

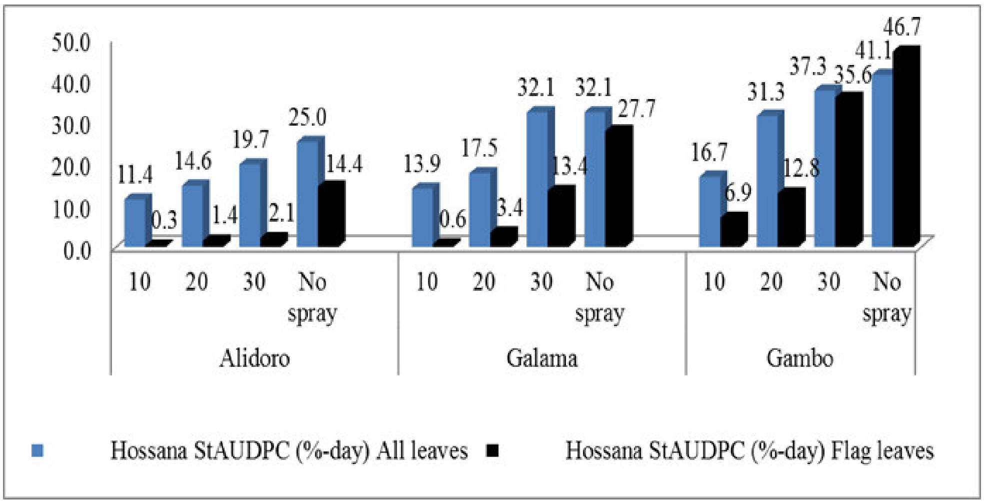
| Variety | Spray interval (day) | Hossana | | | | | Angecha | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Disease progress rate (gompit/ day) | SE of rate | $R^2$(%) | Significance(p) | Intercept | Disease progress rate (gompit/ day) | SE of rate | $R^2$(%) | Significance(p) | Intercept |
| Alidoro | 10 | 0.021 | 0.001 | 89.92 | 0.0001 | -1.29 | 0.020 | 0.001 | 96.55 | 0.0001 | -2.63 |
| | 20 | 0.021 | 0.002 | 87.29 | 0.0001 | -7.16 | 0.026 | 0.001 | 94.54 | 0.0001 | -2.97 |
| | 30 | 0.029 | 0.002 | 94.12 | 0.0001 | -2.87 | 0.028 | 0.002 | 94.04 | 0.0001 | -3.02 |
| | No spray | 0.041 | 0.002 | 95.63 | 0.0001 | -4.12 | 0.030 | 0.001 | 96.23 | 0.0001 | -3.20 |
| Galama | 10 | 0.023 | 0.001 | 95.00 | 0.0001 | -1.94 | 0.021 | 0.001 | 97.72 | 0.0001 | -2.63 |
| | 20 | 0.028 | 0.002 | 86.61 | 0.0001 | -1.81 | 0.036 | 0.001 | 97.70 | 0.0001 | -3.53 |
| | 30 | 0.051 | 0.002 | 97.14 | 0.0001 | -7.37 | 0.042 | 0.001 | 98.29 | 0.0001 | -3.90 |
| | No spray | 0.054 | 0.002 | 96.77 | 0.0001 | -6.69 | 0.047 | 0.002 | 96.60 | 0.0001 | -4.25 |
| Gambo | 10 | 0.023 | 0.001 | 91.56 | 0.0001 | -1.18 | 0.021 | 0.001 | 94.99 | 0.0001 | -2.57 |
| | 20 | 0.046 | 0.002 | 96.48 | 0.0001 | -4.93 | 0.040 | 0.002 | 94.70 | 0.0001 | -3.61 |
| | 30 | 0.054 | 0.002 | 96.65 | 0.0001 | -3.54 | 0.042 | 0.002 | 96.75 | 0.0001 | -3.78 |
| | No spray | 0.058 | 0.003 | 95.27 | 0.0001 | -6.14 | 0.046 | 0.002 | 97.60 | 0.0001 | -3.93 |

Table 2 *Septoria tritici* progress rate on flag leaf of three bread wheat varieties under natural epidemic and different fungicide spray intervals (days) at Hossana and Angecha in 2012.

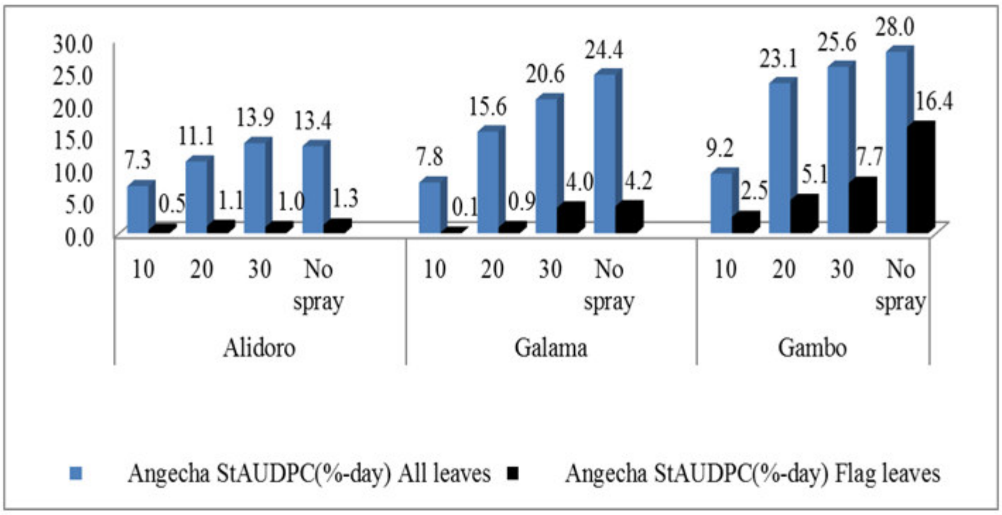
| Variety | Spray interval (day) | Hossana | | | | | Angecha | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Disease progress rate (gompit/day) | SE of rate | $R^2$(%) | Significance(p) | Intercept | Disease progress rate (gompit/day) | SE of rate | $R^2$(%) | Significance (p) | Intercept |
| Alidoro | 10 | 0.002 | 0.102 | 0.02 | 0.979$^{ns}$ | -1.29 | 0.040 | 0.004 | 95.97 | 0.0006 | -5.48 |
| | 20 | 0.061 | 0.013 | 83.78 | 0.0105 | -7.16 | 0.037 | 0.005 | 94.30 | 0.0012 | -5.01 |
| | 30 | 0.017 | 0.008 | 39.47 | 0.700 | -2.87 | 0.029 | 0.008 | 77.06 | 0.0215 | -0.26 |
| | No spray | 0.039 | 0.003 | 92.80 | 0.0001 | -4.12 | 0.051 | 0.011 | 83.73 | 0.0105 | -6.37 |
| Galama | 10 | 0.005 | 0.016 | 2.74 | 0.753$^{ns}$ | -1.94 | 0 | 0 | 0 | 0 | 0 |
| | 20 | 0.008 | 0.016 | 2.79 | 0.603ns | -1.81 | 0.029 | 0.004 | 86.52 | 0.0003 | -4.25 |
| | 30 | 0.074 | 0.006 | 93.58 | 0.0001 | -7.37 | 0.034 | 0.005 | 88.00 | 0.0002 | -4.41 |
| | No spray | 0.072 | 0.007 | 89.83 | 0.0001 | -6.69 | 0.045 | 0.006 | 88.35 | 0.0002 | -5.48 |
| Gambo | 10 | 0.004 | 0.121 | 0.78 | 0.7540$^{ns}$ | -1.18 | 0.06 | 0.007 | 92.44 | 0.0001 | -7.71 |
| | 20 | 0.047 | 0.003 | 93.67 | 0.0001 | -4.93 | 0.041 | 0.003 | 93.66 | 0.0001 | -5.04 |
| | 30 | 0.041 | 0.003 | 94.39 | 0.0001 | -3.54 | 0.025 | 0.003 | 87.38 | 0.0001 | -3.32 |
| | No spray | 0.074 | 0.007 | 89.71 | 0.0001 | -6.14 | 0.049 | 0.004 | 95.02 | 0.0001 | -5.19 |

Here:- SE = standard error of the rate, $R^2$ = Coefficient of determination, ns = non significant

(A)



(B)




Here:- StAUDPC = Standardised area under disease progress curve,

Figure 1. Standardised Area under disease progress curve (StAUDPC) on all and flag leaves of three bread wheat varieties at Hossanna (A) and Angecha (B) in 2012

3.3.1. Grain yield

The most important and economic parameter, which affected by disease is grain yield. In this study, it was most significantly affected by *Septoria tritici* blotch. However relative grain yield loss was occurred on all treatments; there was significant difference among treatments.

At Hossana, the highest grain yield of 49, 51 and 54qt/ha was recorded on every 10 days intervals sprayed plots of Alidoro, Galama and Gambo varieties compared with their corresponding plots; respectively. Significantly lowest grain yield of 32.3 qt/ha was recorded on unsprayed plots of Gambo, followed by its every 30 days sprayed plot (37.6qt/ha) and then unsprayed plots of Galama (36.7qt/ha). This showed significant effect of the disease on the grain yield of bread wheat on an area (Table 1). At Angecha the higst grain yield of 54qt/ha was recoded on every 10 days sprayed plot of variety Gambo while significantly the lowest grain yield of 42qt/ha recorded on its natural epidemics plot (Table 2).

## 4. Summery and Conclusions

At both Hosanna and Angecha, STB was appeared on all of the three varieties simultaneously on the whole field. But it was about two weeks earlier at Hossana than Angecha. It was September 03 2012 when the onset of STB appeared at Hosanna. At the time, the crop was at tillering stage. During the study, at cropping season weather condition was rainy & cool with average maximum monthly temperature of 20ºC - 25ºC. It is best suitable for the development of *Septoria tritci* blotch. In all treatments, epidemic levels showed consistent and inversely related with frequency of fungicide spray levels at both locations. It was also affected by resistant level of the three varieties. In all the cases the highest severity was shown on unsprayed plot of Gambo. The result of this study showed that, high STB disease epidemics with fast progress rate over time was occurred on all the studied varieties; including variety Alidoro that was previously reported as moderately resistant on other locations. Therefore, giving more attention to develop different STB management strategies including breeding and screening of STB resistant varieties for these areas is important. The disease considerably reduce the grain yield from 54qt/ha to 32.3qt/ha on susceptible variety, gambo.

Finally, however weather condition was favourable at Angecha STB disease intensity was lower than its intensity at Hosanna. The most probable reasons for this are genetic variation on virulence level among local STB pathogen in the two locations, low inoculum potential at Angecha, or STB is affected by soil type. Therefore, all these need further investigation. Moreover, the effect of STB on quality of the grain needs further investigation.

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